THE LIMITS OF SOCIAL SCIENCE. I

O. FRED BOUCKE
State College, Pennsylvania

ABSTRACT

Introduction: The progress of social science so far has consisted in an improved qualitative analysis rather than in a growing exactness of quantitative measurements. A larger fund of data has been used, but the method and results are in the main still those of much earlier investigators. The question arises: Is this inevitable, and if so, why? What is the nature of social laws?

Argument: Natural Science. To understand the limits of social science we must first study the aims and methods of *natural* science. This latter aims chiefly at the discovery of types of events or of connections, calling them causal relations or laws. The laws represent groups of things or physical relations as such, or magnitudes whose relative changes are uniform. Rates of change are referred to other concomitants (antecedents or consequents) with figure as "conditions." Not all natural sciences obtain equally precise results, for the events treated as units, and the units of time and space, vary in make-up, in stability, and in definiteness of size. Causation, however, is never anything more than a statement of the inter-connections themselves, with emphasis (1) on specific members of the group known as a law, and (2) on a plurality of causes or of effects. Furthermore, natural science always attains its ends by coupling inference with measurement. Inference alone is insufficient; but if variations of things and magnitudes are introduced under proper control of "conditions," a certain uniformity of relations will appear, and this leads to generalizations which, though having partly a subjective origin, have objective validity also. Most laws of nature indeed may be verified by the senses, directly or indirectly, and suggest practical applications.

INTRODUCTION: THE RESULTS OF SOCIAL SCIENCE UP TO DATE

Let us call history, politics, sociology, and economics the social sciences par excellence. There are of course others of a more special sort such as anthropology, ethnology, criminology, and so on. But let us ignore them because they are not important as test cases for the achievements and possibilities of social science, or because their results will depend in goodly part upon those of the broader fields mentioned first. The question then may be asked today as it has been asked before: What exactly justifies our calling these disciplines sciences? What have they so far accomplished that is strictly scientific? And what are the limits beyond which we dare not hope to attain accurate generalizations about social events, regardless of our efforts and abilities?

Notable progress in the study of human relations has, to be sure, been made during the last 150 years. It would be unjust to the work of investigators past and present to put the literature of recent generations on a level with that of earlier days. The temper of discussion, the methods of inquiry, the wealth of data unearthed and correlated, and the benefits that have indirectly accrued to mankind from these modern searchings into social processes—they all mean an improvement that we may well be proud of. It is not that the great minds who have so far dedicated their lives to the exploration of human records labored in vain, or did something scarcely worth while. No. In questioning the powers of social research we must not underrate what has already been brought to light. We should not suspect the pioneers of having lacked acumen, or of having been careless in their ways.

Nevertheless, the arguments once used to elucidate the limitations of social science have partly lost force through changes in other basic fields. The present for this reason is an opportune time to review the problem, and to emphasize new points in an otherwise familiar thesis. The hopes of contemporaries for a science of melioration should not be raised too high, lest our disappointment be equally great. To awaken to the defects of existing systems of economy, jurisprudence, theology, and ethics is one thing; but to believe that betterment is certain if we but wish it, if we study diligently the facts of social life, is quite another thing. What today as much as ever we should remember is the radical difference between natural and social sciences in fundamental respects. The case for the latter is none too good even when judged by its best examples of exposition, as now printed and preached; but it is weakened still more by an impartial methodological treatment. What offhand may seem an astonishing paucity of results in social science may then please us as the best possible under the circumstances. We shall perhaps be chagrined over our shortcomings, but we shall quit trying for the unattainable, enjoying the while the gains that go with every loss.

Up to date certainly social scientists as a class have promised more than they could fulfil. This has been a rather common mistake, and one that need not surprise us. It began with the beliefs

of the eighteenth century that a law of progress really existed and might be found upon investigation. We must never forget that the birth of social science is due to a once ardent faith in a parallel between the laws of physics and the principles of human behavior. The Newtonian system, it was held, had a counterpart in the sphere of social relations. Laws were to be stated for the latter which should closely resemble those of the former. Regularity of individual events or of groups of events was an assumption which men started out with before launching upon their journey of discovery. And though in the course of further inquiries an appreciable change of opinion took place, yet the term science continued to be applied to social studies. Today we are still inclined to aim at achievements which shall compare favorably with those of the physical sciences.

Circumstantial evidence to this effect might be proffered in current literature on the subject. We might take at random from our shelves volumes of recent publication and ask ourselves whether they have not overstated the case for social science. But more especially, also, we might bear in mind the age of these sciences, and reflect meekly on what they have produced in definite and incontestable formulations of law. Noting the decades gone by since the dawn of social science we might compare its work so far with that of other inquiries. What progress, for instance, did physics make from, say, 1630 to 1780? What are the great milestones in the development of chemistry between 1770 and 1920? What did geologists contribute to human knowledge since the days of Lyell? What must biology be credited with for a similar period? Plainly, for these fields a century and a half has meant marked advance, astounding discoveries, and applications that may well be the envy of every toiler, be he scientist or philosopher. But what services exactly has social science rendered?

For our purposes history of course need not be considered at all. For most of us will grant at once that the historian is a scientist only in his method or in spirit, and not in his aims and results. Science, if it is anything, comprises a body of generalizations. It involves measurements of quantitative relations which are uniform, however variable their external appearances. Science correlates events as such, or relative magnitudes of things and classes. It seeks types

and logical grounds for prediction, while history is most interested in the individual, be it an object, a situation, an event, or a human being. History therefore is not properly speaking a science whose limits need discussing. But we are directly concerned with politics, sociology, and economics. If we ponder on the what and how of social science, it must be with special reference to these three subjects.

Now, judging by results, these three sciences surely cannot be said to have realized their original program. That is, not if we treat them as sciences in the narrower meaning of the word. For as to politics, it has hardly ever been more than a description of existing institutions. It has told us at length about the mechanism of this or that government. It has gone into details that are interesting, and by its comparisons has suggested improvements now and then. But it has not proceeded according to the rules of a true science, nor netted generalizations valid for a long time, for all nations. An analysis of principles has not seldom been sacrificed for the sake of norms conceived ethically. The ethical undercurrent has hindered rather than helped politics as a would-be science; while abstractions have not gone far enough because of a dearth of verifiable materials. So-called political philosophy in this respect did better. It managed somehow to strike bedrock in speculations about human nature, and left an outlook that was broadening and inspiring, even if not immediately productive of universal truths. But this being so, is political philosophy in any garb more scientific than descriptive politics? Some will possibly say yes. Others will point to the personal bias, to the passions of most publicists, and correspondingly discount their utterance on final problems. In any case, politics does not stand as secure as seems desirable. Its value as a study of particulars is undeniable, but its scientific character has not been proved.

Has sociology, however, done very much better? Is it really a science and not a philosophy of values, or a depiction of facts? Has the sociologist or economist laid down propositions that will endure, propositions definitely verifiable and quantitatively put?

As suggested before, let us take the most eminent and influential sociological treatises of the last fifty years and see how much in them

is science, and how much philosophy; how much is akin to historical narration, and how much a brief for reforms. We shall find quite a variety of treatments. We shall find little that is scientific according to the requirements of a physicist, and much that is valuable precisely because natural scientists would pronounce it to be unscientific. Incidentally, then, we should confess this at the outset: It is unfair and fatuous to compare the work of natural and social scientists as if they sought like ends with like means. Assuredly, that would be a grave mistake. We must at once recognize differences in subject-matter and standards, and ask merely in what exactly they consist, and what points deserve emphasis today in opposition to claims formerly made.

Thus, if we are at all interested in the future of social inquiries, we must lay aside with mixed feelings the best books that have recently come from the press both in Europe and in Anglo-Saxon countries. On the one hand (we grant) how much toil and care! What range of observations and skill in the presentation of materials! What profusion of facts, of stimulating ideas, and of verities that rank with the finest of poet and seer! How admirable as a whole the work submitted for our critical consideration! And yet, on the other hand, how doubtful the superiority of the finest of these modern treatises over the musings of an Aristotle or Plato! The environmental data, of course, are distinctly of the present moment, and vastly outnumber those of ancient writers. But as a psychological analysis the *Politics* of Aristotle, e.g., is hardly inferior to anything conceived within our own days. Twenty-three centuries seem to have made small difference as regards big things. For there is still today in our volumes a mountain of qualitative analysis, and a molehill of quantitative correlations. Intuition still plays an honorable rôle. Generalization still pertains to individual human nature, not to society the world over. Or, if principles for the latter are announced, they spring from reflection and local experiences rather than from inquiries objectively verified. Statistical tabulations do not mean as much even nowadays as some would have us believe. Indeed, they are rarely worked into the texture of the main argument. Induction is at low ebb, and the deductive method at high tide of popularity. Laws are sparsely used, and not

always frankly stated. The philosophical mood is gaining favor again, while the variety of topics embraced in current surveys is more impressive than logical. It must be admitted, sociology increasingly has borrowed from psychology and economics, and thereby bewildered many a friendly reader. The worth of sociological labors has always been its dynamic interpretation of life, its selection of facts once neglected or not known to exist, and its spirit of truth-seeking and helpfulness. But as a science sociology has not advanced greatly since the pre-Christian era.

Neither have economists reason for congratulating themselves at the expense of their confrères; for especially in these days the science of economics speaks without force of conviction. A period of transition is passing before us that leaves many wishes and few dogmas. Clearly defined fields are no longer as popular as years ago. The exactness of classical, neo-classical, and marginal economics has turned out to be artificial and not in keeping with facts. Catallactics, statics, and the "economic man" are terms used cautiously now, or else are decried as misleading catchwords. We have discarded old notions and turned to new missions. We have qualified theorems so meticulously that little of their original character is left. We are looking for a reconstruction that shall be more truly scientific, though meanwhile entertaining doubts. Commerce and finance as college curricula are devouring economic theory. An adaptation to what *is* threatens to swerve us completely from the hard path of truth for its own sake. Thus economics is no longer setting other social students a shining example. It has failed us, not because it does not possess real advantages in definiteness of scope, nor because of a dearth of scholars in the field, but because many of its crucial tenets have been shown to be proofs rather than laws. Proofs follow from premises and are readily given. But laws turn on facts, and may not always be forthcoming after the facts have been studied. The difference between proof and a law of nature is generic.

THE PROBLEM AND PLAN OF EXPOSITION

A review of the limits of social science, then, is justified by the meagerness of achievements up to date, to say nothing of the logical queries to which we shall now turn. It will be profitable for every

social scientist to ask himself at some stage of his journey: Just where precisely am I going? What aids may I use, and what cannot be attained? Am I for instance a scientist or a philosopher? Are values facts, or must they be treated differently? May I hope to give advice to practical men of affairs, to reformers, and to statesmen? Or are my generalizations necessarily confined to transient things and conditions, so that social laws are both impermanent and vague?

In answering these questions we shall do well to contrast again, as has commonly been done, natural sciences with social sciences. But for one thing the former will have to be divided into two groups according to whether they deal with organic matter or not, and for another thing we shall have to judge the scientific value of a study by its methods no less than by its subject-matter and results. All correlations of science will appear to be either qualitative or quantitative. This distinction is suggested directly by differences in the units of events and in those of time or space. The question of units and their mode of measurement therefore becomes highly important in assigning to any one study its place among sciences. What are called causal and conditional phenomena must be considered mainly from the standpoint of these units and of our method of measuring their interrelations. On the one hand vital phenomena become causal regardless of volitional aspects; on the other hand social happenings will evince a range of variability that interferes greatly with generalizations of a sweeping sort. The nature of our data, indeed, predetermines the nature of means and ends. Not only must the form of inference be distinguished from that of measurement, but in addition our measurements will prove to be of two different kinds. The limits of social science are the outcome largely of such major points in methodology.

A. NATURAL SCIENCE

Chief aims.—If we consider the characteristics of natural science first, we shall be reminded from the start of the fact that all knowledge concerns *groups* of facts or events, and not individual facts. This is true whether we are historians, biologists, crystalographers, or meteorologists. To man the world is necessarily a web of rela-

tions, a vast mosaic of many pieces and designs. Nothing is viewed wholly as an individual. Everything is linked with something else by that sense of temporal and spatial continuity to which we are heir without end. It is groups of events that the man of the street is conscious of; and it is a group of things or qualities that sciences try to correlate in the final stages of their work.

The groups so correlated are always sequences and coexistences. That is, the events occur either in succession, or simultaneously. If it is the former, we call them sequences. If it is the latter, they are known as coexistences. Our mind is so fashioned that all classes of things and their connections must be pictured as either one or the other, or as a combination of the two.

But what interests the scientist most of all is, of course, the regularity of recurrence of such sets of objects or events as he may isolate in space or time. The aim of science is the discovery of laws, i.e., of a demonstration of the invariable connection existing between specified classes of things. The ideal for this purpose is an absolute regularity, and is attained by some sciences. Regularity less than 100 per cent is theoretically not possible, but exists for the perceivable facts of common sense which sometimes are correlated by science. We must certainly grant that these "empirical" laws and partial repetitions of events have a significance second only to that of "exact" laws. And for this reason they are treated as laws.

Qualitative and quantitative analysis.—Furthermore, science always treats of laws or correlations (the two terms may here be used interchangeably) either qualitatively or quantitatively, since it connects either events and qualities as such, or varying quantities of them. It is possible, for instance, to say that water is a compound of two elements, meaning that two events invariably connect so as to form water. This might be considered a case of the coexistence of two things known as hydrogen and oxygen. But the chemist also takes note of a second fact, viz., of a constant proportion of these two elements when reduced to lowest units. Definite amounts of hydrogen and oxygen combine so as to produce a new attribute called water. Thus qualitative and quantitative correlations go together, and are usually part of one law of nature. Qualities or events such as two gases, or sound and density of medium, or metal

and conductivity, are correlated as such. But even more important may be the determination of magnitudes of such things or events. Constant ratios or relative rates of change will have to be figured out and made the basis of a formula. For change is continuous, and the measurement of change a cardinal feature in all science. Accurate knowledge must consist of mutable rather than of stationary conditions. Only in this sense will science reveal regularities of recurrence.

Natural sciences not all equally exact.—What is more, in acknowledging this ideal of precision in scientific enterprise, several reservations must be made at once, lest we overrate our powers, namely, in the first place, there is a difference between the physical or inorganic, and the organic fields of research. The former are the oldest, and deal exclusively with perfect repetitions of events specified in the law. No exception to this regularity exists, except it be due to errors of calculation or correlation. But as soon as we enter the realm of vital phenomena, absolute constancy of interrelations is exceptional rather than common. Indeed, it may logically be out of the question, even though a high degree of regularity, measured on a percentage basis, may be reached. The generalizations of biological inquiries, e.g., do not for the most part indicate such infallible connections between specific events as the physicist or astronomer boasts of. It is not likely, considering all the circumstances. And it deserves particular mention that there are natural sciences which in degree of irregularity of the recurrence of events approach the social sciences. To lump the natural sciences as if they were all equally exact is to ignore a basic principle in methodology.

In the second place, we may note that even some physical sciences find it hazardous to generalize upon a quantitative analysis of relations. Meteorology, for example, is handicapped in this respect. As meteorologists we know, to be sure, what classes of things or of events enter into any possible situation we may want to study. We know all the physical facts involved. We know what temperature is, what the constituents of the atmosphere are, what winds signify, or electrical disturbances or radiation of heat or fog or particles of matter suspended in the air. All these elements are known, and for the largest part may be ignored in the measurements

necessary to a forecast. But we cannot compute the quantities of each set of physical facts per time and space unit. We are at a loss to understand the relative changes occurring in outdoor nature, and hence must be circumspect in our weather reports.

Units for measurement and generalization.—In the third place—and most important—all regularities of science are conditional and subjective from one standpoint. For if we speak of perfectly regular recurrences as the test of a true law of nature, we must mean recurrences of *select* events or groups of them; and the question now arises: Do events occur actually as grouped by science? What is the purpose of selection, and what kind of events are we then talking about? Viewing our admirable laws of nature in this light we shall realize the artificiality of all scientific formulas, even while allowing to the natural sciences a mastery that can never be claimed by social inquiries.

Let us note, then, that *for purposes of correlation* sciences are generally concerned with three sorts of units. Other units which constitute standards of measurement, or are derived from them, have no significance here. It is not the meter or the kilogram that must engage our attention just now, although these are admittedly important as aids to measurement. But apart from such aids we must recognize three classes of units, since they explain in no small degree the difference between social and natural sciences. And these units we shall designate here as the irreducible ones of a physical or chemical make-up, and as composite units of either a physical or non-physical make-up. In the first grouping we contrast chemical with physical concepts, in the second, physical with psychical aspects.

The chemist conducts a qualitative or quantitative analysis by disintegrating substances and finding homogeneous elements. He speaks of elements as the materials out of which compounds are built. The elements furthermore are pictured as non-divisible entities called "atoms," which in various numbers and proportions of mass unite with one another. Thus regular recurrences of certain combinations are explained. The units of chemistry are not only infinitely small, but represent matter subject to a continuous metamorphosis.

The irreducible units of other inorganic sciences do not refer to kinds of matter, but to magnitudes of energy. They owe their origin to a fundamental feature, namely, to a conflict of forces that manifests itself as heat or motion or light. This motion may be identified with tangible bodies, solid or liquid or gaseous, with immaterial entities of an electrical nature, or with changes of such magnitudes. We may attribute it to solar heat, or to still remoter facts. We may study it in any form we like. But in all cases our final unit for measurement is one of energy. The chemical standard of attributes and of the classification of substances is not applicable. As physicists we do not care whether gas is a simple or a complex affair, whether light is material or non-material in the ordinary sense of the word. We merely take these classes of matter to be energy in motion, and correlate different forms of it quantitatively. The behavior of light, for instance, is correlated with different bodies classified as we please. We study its velocity and deflections in translucent or opaque bodies, in magnetic fields, or in articles of commerce. Physical phenomena notably are observed with regard to quantitative changes per time, though a purely qualitative analysis has its usefulness, as the applications of industry have shown again and again.

If now, however, we pass over to biology or geology or physiology, or to any of their subdivisions, we shall also encounter a third class of units which is neither chemical nor physical according to previous definition. It is not an irreducible thing at all. Instead it is a composite of such units as the primary natural sciences deal with, or else any object or relation different from atoms or electrons or lines of force. For some sciences these composites are tangible *things* chiefly; for others intangible *relations* chiefly. Generally speaking they are known to common sense, and figure prominently in our everyday problems. But some of them are distinctly the product of scientific abstraction.

The third class of units has a place in the natural sciences as well as in the social. In the one case they are always physical facts; in the other they are either physical or psychic facts. Many special sciences, and applications of them, center in the careful quantitative and qualitative analysis of these units and of their interdependen-

cies. But always they are composite things or relations unsuitable for measurement by physical or chemical standards. A physician thus treats cells as units, or organs of the body, or the blood-stream, or chains of ideas, and so on. For the ecologist plants and animals, soil and weather are units. The geneticist treats chromosomes or genes as units, correlating them with traits developing after birth, or with a prenatal food supply. A psychologist reduces consciousness to neurons and excitations, to an association of ideas, or to percepts and images. For the sociologist a unit may be the climate of a given region, or a level of economic living, or the family or clan, or a custom such as a taboo, or a war or a crime wave, etc. In each case the objects as apprehended by our senses, or immaterial relations concerning them, count as units. Whole situations figure as a single fact for purposes of measurement and correlation. What may be called event-complexes—such as a crime or a linkage of mental aptitudes or a disease or a religious institution—are treated as classes fit for comparison and quantitative measurement. Both natural and social sciences have use for such composite units. True, however, that in the former they are ordinarily less comprehensive and heterogeneous than in the latter, and correspondingly are more easily measurable. A histologist, for example, has an advantage here over a psychologist, and the psychologist over a sociologist.

Units of time and space.—But again. Units of events are not the only ones to consider. We must also give a thought to temporal and spatial units, since these too differ for our main groups of sciences, viz., the natural and social.

For the first these units of time and space are definite or small; for the second indefinite or large. A chemist, though not caring particularly for time intervals, cannot ignore distances. Though the changes going on among substances miles apart may be of the very kind which constitute his subject-matter, they are not made a test case for connections and laws, because of the distance between them. If substances are not contiguous or in close juxtaposition, their interactions cannot provide a basis for either analysis or inference. The astronomer, on the other hand, is interested in both space and time in a superlative degree, and will measure them nicely for the events forming his problem. The size of his spatial

or temporal units corresponds somewhat to that of his event-units. But like a physicist he establishes a definite quantitative relation between changes in events and periods of time. The mechanistic view of things makes this possible for him. All laws being stated as constants of correlation quantitatively as well as qualitatively, their relative rates of change may be expressed for almost any unit of time. The grouping itself of events will often have reference to a short span of time, but the ratios of their magnitudes are calculable for much larger ones, or vice versa. Thus the oldest natural sciences represent a maximum of definiteness in the use of time- or space-units, while geology and the biological inquiries in this respect may be said to take a middle position between physics and social inquiries. As we shall see later on, the choice of time- and space-units is intimately connected with the nature of our event-units, so that both kinds will be either clearly defined or vague and perhaps immeasurable.

But such being the truth about our several sorts of units for correlation, we should acknowledge candidly the human side, the conditional nature, of our laws and formulas. It should convince us that sequences and coexistences do not really occur in nature as described by a scientist. He does not present the interconnections of events exactly as they take place before our eyes. He might conceivably do so, and sometimes does proceed in that manner either as an experimentalist or as a recorder of social happenings. But for the most part the natural sciences, like others, detach their subject from surrounding factors. They not only measure units too minute for our naked senses; they not only use conceptual units, as it were, in lieu of perceptual units; they also segregate events for the sake of getting at principles. For a mechanistic interpretation this is quite permissible and indeed necessary. Whether it can be done with as much sanction of logic in the study of social relations is another question. But in general the fact of abstraction remains. A certain subjectivity of valuation is unavoidable. All knowledge is at least as much a creation of a mind as a reflection of data objectively real. If the natural sciences, therefore, differ from others in objectivity of truth, it can be only in degree.

"Conditional" phenomena.—Yet there is one additional point favoring natural science, which must now be mentioned, namely, for natural science the "conditioning facts" of a law or of a particular correlation are as a rule definitely ascertainable. If a chemist isolates a substance and its immediate concomitants, he does not intend to ignore others. On the contrary, his experiments include the analysis of variables treated at a given moment as a condition. This latter is understood to be itself an expression of laws, of laws which may or may not connect directly with the one under surveillance. Nothing can be accidental, and nothing can modify a law of nature except in so far as the absolute magnitudes or the qualities of our *perceptual* phenomena are concerned. The external appearances of things will change with conditions, but the ratios and qualitative correlations will remain constant, if a law for them exists. A falling feather thus does not prove an exception to the law of acceleration of falling bodies. We merely allow for new events and quantities, in order to subsume a special group of magnitude under a general theorem. Natural scientists ordinarily can measure these conditions, as well as itemize their components. We say ordinarily, because exceptions are known even for natural science. A meteorologist for instance will have difficulties, and hence proves an unreliable prophet. The geologist is not nearly as well off as a physicist, and in genetics (as a branch of biology) the problem of conditions becomes so intricate as to defy solution at times. Nevertheless, the conditioning factors prove in general less irksome for natural than for social scientists. They do not prevent us from being abstract and precise. They do not invalidate generalizations made on the basis of artificially controlled experiments. They are no reason for doubting the reality of laws which govern thousands and millions of event-groups in the world about us.

Causation.—What is known as causation is nothing but this regularity of the recurrence of events constituting a law of nature. Apart from the general interpretation of causation as a uniformity of nature, its real meaning is the invariable connection of events, *a b*, or *c*, or of *abc*, with *d*, *e*, or *f*, or with *def*. To say that something is the cause or the effect is to point out such relations. Either we refer

to sequences, in which case the antecedents are the causes and the consequents the effects, or we refer to coexistences. In the latter case we do not usually distinguish between cause and effect; indeed, logicians have denied a causal character to such coexistences as the properties of a metal or the anatomical parts of an organism. But even here we have causation, provided the connections are unexceptional. The problem of spatial units involved is, as we have seen, not essentially different from that of time-units. There is no more reason for making sequences causal than for predicating it of coexistents. Causation is regularity of connection relating to given event-units and time- and space-units. That is all.

Or to repeat this thought in greater detail: Our idea of what comes first and what last is always colored by an arbitrary point in time. We commonly take the present as our point of reckoning, and furthermore set bounds to the stretch of time within which sequences must be completed. If a point for successions is marked in time, then one particular event will always precede or follow another. But if we think of time as whole, or review the cycles of sequences that have already occurred, we shall find it quite possible to connect the consequent of one cycle with the antecedent of the next cycle. In doing this we shall be prompted to ask just what time means in causation, and whether sequences are as objective as we take them to be. But in addition we shall also be impressed with the artificial nature of those time-units connecting *abc* with *def*. We shall see that causality depends very much upon preconceived relations of specific events in time. A certain periodicity of law or correlations results from this one-sided way of sensing them. For strictly physical events a reversibility of events is logically not impossible. It is only in noting invariable connections between physical and *psychic* events that a progressive feature of causation arises which opens up new vistas for science. But even then the general fact is as stated. A causal explanation is always an allusion to regular connections. To ask why something happens is to ask what invariably precedes or follows, or occurs simultaneously with, something else. This is the sum and substance of the problem. We do not add anything to a correlation by dissecting it causally. We bring no new element into the situation. We merely select particu-

lar links in a chain known as a law of nature as either cause or effect, varying our selection according to purposes and points of view.

Again, causation is most frequently plural. That is, one cause may have several effects, and one effect may have several causes, so far as the connection of perceivable events is concerned. For the things and relations known to common sense or used by science for measurement a plural dependence of any one fact is almost certain. We rarely can prove the existence of only one antecedent, even after our time-units have been marked off. We may assume a one-to-one correspondence ultimately, if we picture the cosmos as an interplay of mechanical forces or of a finite number of material events. We may argue too that plurality of causes or effects varies with kinds of events, and that in every case this plurality is determinate and constant. That may well be. But as a principle and problem of imputation plurality must none the less bring up difficulties, and show the limitations even of natural science. Not only does it differ from social sciences merely in the degree of plurality of causal relations, but what is more, it must take greater pains in locating the plural ties, since it aims at absolute regularity of recurrence and deals with comparatively few homogeneous units of events. The units and their interrelations are actually simpler than those of social science, but for this reason causation must be made more specific. Generalizations based on an insufficient grasp of all causal connections will speedily be overthrown. Everything depends on complete knowledge and on precision of measurements.

Methods.—The methods for realizing this ideal have been variously described by logicians as well as by scientists. It is not necessary that we review them in detail. But it is certainly worth while in this connection to emphasize a difference between, first, inference and measurement, and secondly, the inorganic and the organic sciences.[1]

[1] This classification is logical, and does not interfere with a designation of a physical science as an "organic" one. Chemistry may thus be divided into organic and inorganic. But this is a reference to matter, not to methods. The chemist treats life-processes exactly as he treats any chemical changes. His viewpoint is mechanistic and physical, even though he applies it to vital phenomena. A biologist on the other hand studies relations which are more than chemical, or not chemical at all. Hence the cleavage line between organic and inorganic sciences.

Inference is everywhere the same. Men do not differ in their reasoning, though their choice and rating of facts, and their methods of measurement will vary greatly. Whether engaged in scientific tasks or pursuing our business for profit, we nearly always combine induction with deduction, and observe the rules of the syllogism, of enumeration and analogy or substitution. The separation of induction and deduction is a good methodological device, but has no foundation in real life. This becomes evident upon a little inquiry. We always unite in our thinking particularization and generalization. We have facts before us. We compare them and venture upon classifications. We start with certain assumptions regarding the facts, and let experimentation or other facts already at hand speak for or against the truth of our premises. We deduce conclusions from premises, and verify the former by perceivable data, where possible. We are reasoning all the while in a dual manner, counting repetitions and inferring from them; tracing partial or complete resemblances and continuing our inductions on the principle of enumeration; classing events according to properties, and subsuming one class under another so as to find a universal for a particular—in other words, to arrive at a definite conclusion regarding specified relations. All this has been shown again and again.

But this means, then, that measurements are indispensable, and that aside from correct inference we must agree upon data and their relative weights. Logic has proved inadequate precisely because it is interested in the formal aspect of thought only, and not in contents or modes of measurement. Hence science stresses the latter, and in its progress has paid little attention to the dicta of logicians. Hence also grave differences of opinion and of tangible results may arise for the exponents of any one science. And hence again different sciences may come to conclusions altogether irreconcilable, even though they all rely on like principles of reasoning. They swear by the same logic, but differ on choice and measurement of facts.

The distinction between organic and inorganic sciences is connected with this need of adding measurement to inference; but it is justified more especially by the fact that the measurements themselves differ even within sciences other than the social. Differences in kinds of materials as well as in modes of measurement bring this

about. It is misleading to contrast natural science as a whole with social science, as if the former were in all fields equally "exact." We know this to be untrue. We know that owing to differences in event-units and in time- or space-units biologists and geologists cannot figure as closely as physicists or chemists. We know that the problems are not the same, nor the technical devices for achieving universals of truth. A line between living and inanimate matter must be drawn in spite of aspects of continuity. Whatever a materialistic conception may enjoin us to do to prove unity, the dual aspect of things covers forms of existence no less than problems of knowledge. Any inquiry concerning vital phenomena must treat of things and relations which are less homogeneous, more comprehensive and variable than those of astronomy or physics. Hence our methods and results differ appreciably even for different natural sciences. The results of biology may impress us less than those of chemistry because its measurable units are less definite. Experimentation is rightly associated with a maximum of precision when dealing with inert facts. The more conspicuous the life-data in our calculations, the less notable the accuracy of our inductions.

Still, for all natural sciences a considerable degree of accuracy is reached. Their methods guarantee this, and are proverbially standardized to this end. Events are controlled and isolated. They are modified more or less at will, and subjected to measurements of diverse kinds, all of them tending toward a reduction of particulars to principles. Experiments are repeated, and both qualitative and quantitative variations introduced for our examination. Events are added or subtracted. Canons of induction are then applied so as to sift causality from "accident," and invariable concomitants from irregular ones. Our elimination or inclusion of factors in order to observe changes is nothing but a form of measurement. The conditions which vary are definite magnitudes that illustrate other laws of nature, besides throwing light on the group which we are studying for the moment. In short, by variation, one change in one event or set of events is compared with changes in others, the amounts of change leading the way to a generalization on events and their relative magnitudes. Exceptions to a law thus found will be examined and considered as instances of

other laws, the new relations being due to plurality of "causes," i.e., of connections not formerly suspected or at any rate not as yet measured for their constants. Perceptual relations must in any case be resolved into one of indivisible units. If this is not done, plurality grows enormously and mocks our reasoning. Hence it has often been said that science (and particularly natural science) aims at a simplification of relations. It unifies our knowledge by subsuming one class under another. It gradually culls constants from variables, perfect from imperfect correlation, universally valid from locally prevalent truths. Its laws are contingent, but nevertheless exact when due allowance for the variants of a perceptual world has been made. Thus natural sciences have a reputation for truth objectively sensed, for widespread agreement on fundamentals, and for powers of prediction and a practical application of results.

[*To be continued*]